

## **Historic, Archive Document**

Do not assume content reflects current scientific knowledge, policies, or practices.



RC  
CSR-0  
A

ADMINISTRATIVELY CONFIDENTIAL

24510 APPRAISAL OF RESEARCH NEEDS TO DEAL WITH THE EUROPEAN  
CORN BORER AND OTHER CORN INSECT PROBLEMS  $\Delta/D \neq C$

ARS

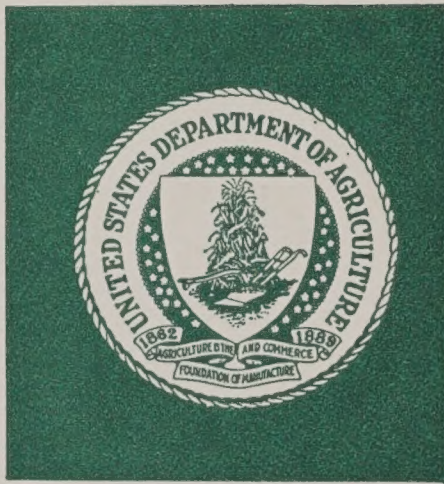
Prepared by  
Committee on Corn Insect Research Needs.  
Appointed by  
Director, Entomology Research Division  
in response to  
Congressional Request for a Report on  
Future Action Needed to Meet the Corn  
Insect Problem

December 30, 1958

AD-33 Bookplate  
(1-63)

**NATIONAL**

**A  
G  
R  
I  
C  
U  
L  
T  
U  
R  
A  
L**



**LIBRARY**

## CONTENTS

	<u>Page</u>
SUMMARY .....	1
INTRODUCTION .....	4
Purpose, Objectives and Procedure .....	4
Importance of Corn to the Nation .....	6
THE CORN INSECT PROBLEMS .....	7
NATURE AND SCOPE OF CORN INSECT RESEARCH NOW UNDERWAY .....	9
Recent Advances in Control Measures for Corn Insects ....	9
Current Status of Corn Insect Research .....	9
Nature of Research on Corn Insects Underway by the Department of Agriculture .....	14
Nature of Research on Corn Insects Underway by State Experiment Stations .....	15
Nature of Research on Corn Insects by Industry .....	15
OVERALL RESEARCH NEEDS AS DETERMINED BY THE STUDY .....	16
NATURE OF THE WORK AND REQUIREMENTS FOR A PROPOSED FEDERAL PROGRAM OF RESEARCH .....	26
Additional Support for Existing Work .....	27
Midwest Federal Laboratory .....	27
Southern Federal Laboratory .....	30
Abstracting and Translating Literature on Corn Insects ..	33
Classification of Corn Insects .....	33
RELATIONSHIP OF PROPOSED FEDERAL PROGRAM TO STATE PROGRAMS ...	34
APPLICATION OF RESEARCH INFORMATION ON CORN INSECTS TO OTHER CROPS .....	34

U. S. DEPT. OF AGRICULTURE  
NATIONAL AGRICULTURAL LIBRARY

JAN 24 1978



APPRAISAL OF RESEARCH NEEDS TO DEAL WITH THE EUROPEAN CORN  
BORER AND OTHER CORN INSECT PROBLEMS

SUMMARY

Corn is grown in every state in the United States, occupying about 85,000,000 acres or one-fifth of the crop land. Its annual value of almost five billion dollars makes it vital to the economy of the United States. At least 25 major species of insects attack corn causing an estimated annual loss of more than \$900,000,000.

The total amount invested in corn insect research by the states and by the Federal Government is less than \$800,000 a year. Approximately 75 percent of this is state-supported research. Progress has been made toward the solution of some of the corn insect problems but more effective, more economical and less hazardous control measures are needed to satisfactorily meet the problems. The most urgent need is to develop research programs that will provide basic information on which to draw in efforts to better meet the problems of control.

On the basis of this study which reflects the opinions of the many scientists consulted the committee has developed a program of corn insect research that is regarded appropriate for Federal support. The program suggested provides for: (1) some additional support for the corn insect projects now underway in order to permit the employment of more subprofessional assistants and to provide for more operating funds for the scientists now engaged on corn insect research; (2) a major expansion of research and the construction of necessary laboratory facilities for an adequate corn insect program in the Midwest; (3) a major expansion of research and the construction of necessary laboratory facilities for an adequate corn insect program in the South.

The study showed that the European corn borer, corn earworm, soil insects, fall armyworm, corn leaf aphid, southwestern corn borer and rice weevil were the most destructive of the many corn insects. These seven insects are of regional and national importance. The Federal Government could contribute most to the overall need for research by intensifying certain phases of research effort on these species.

Basic and applied research on the major pests should include the following broad lines of study:

1. Biology and ecology of the major corn insect species.



2. Development of more economical and satisfactory chemical control methods, especially chemicals that can be used against corn pests without leaving harmful residues on the forage.
3. Development of corn inbreds and hybrids highly resistant to insect damage, including the nature and cause of resistance.
4. Development of effective biological methods of control, with particular emphasis on insect disease.

To conduct research on these problems the cooperative efforts of entomologists, chemists, biochemists, plant breeders, geneticists, cytogeneticists, agricultural engineers, bacteriologists, plant pathologists and plant physiologists will be required. Close cooperation with investigators in the states and with industry would be necessary.

Basic and applied research on broad problems along lines proposed for the major pests could be conducted at two central locations; one in the midwestern corn belt and another in the Southern States. Information obtained would be made available to other investigators on corn insects for consideration and guidance in connection with research in other areas.

The type of research on the corn insect problems considered appropriate for Federal attention and support and the estimate of the number of senior scientists required to carry out the research needed are listed below for both the midwest and southern regions:

Type of Research	Number of Senior Scientists
------------------	-----------------------------

Midwest

Biology and ecology	4
Chemical control	3.25
Varietal resistance control	4.75
Biological control	<u>2</u>
Total	14.0

South

Biology and ecology	3
Chemical control	2.75
Varietal resistance control	3.75
Biological control	<u>1.5</u>
Total	11.0



In order to carry out the Federal programs of research outlined, adequate facilities will be required in both the Midwest and South. The facilities should provide for necessary laboratories and offices, greenhouses and headhouses, storage, shop, and garage space and land required for the research programs and for the structures.

The initiation of Federal research on the insects mentioned and on the areas of study proposed would not meet all of the research needs for an overall program. The study has shown that at least 17 other insects are injurious to corn in one or more states and these as well as many phases of study on the seven major pests included in the proposed Federal program need research attention. In order to initiate or strengthen research on the many corn insect problems not included in the proposed Federal program, the committee urges that State Agricultural Experiment Stations study the matter and obtain through appropriate sources such additional support as circumstances warrant for their state.

The seven insects suggested for study in this proposed program feed on many crops in addition to corn. Basic findings and control methods developed in the corn insect program could, therefore, be expected to be applicable with some necessary modifications to the protection of other crops from insect damage.



APPRAISAL OF RESEARCH NEEDS TO DEAL WITH THE EUROPEAN CORN  
BORER AND OTHER CORN INSECT PROBLEMS

INTRODUCTION

Purpose, Objectives and Procedure. This is a report of the findings of a study group appointed to: (1) estimate the importance of insects in the production of corn in the United States, (2) review the nature and extent of research on corn insects presently under way by state and Federal agencies and by industry, (3) consult with and obtain the views of specialists concerned with corn insects as to the corn insect problems needing research attention, and (4) estimate the requirements for a Federal program of research to deal with major corn insect problems on the national level.

(500)  
This study was conducted in response to the request of the House Subcommittee on Agricultural Appropriations in its report on the Appropriation Bill for fiscal year 1959. The statement of this committee was as follows:

"Research on the eradication of the corn borer and other corn insects also needs to be increased. The Department is requested to study this matter and submit a special report to Congress next year as to future action needed to meet this problem."

by A working group consisting of R. G. Dahms and J. W. Ingram of the Department's Entomology Research Division, Agricultural Research Service, and T. A. Brindley, a joint employee of the Entomology Research Division and the Iowa Agricultural Experiment Station, was appointed by the Director of the Entomology Research Division to make a study of corn insect problems throughout the United States. The Director of the Iowa Station concurred in the appointment of the joint employee on the working group. Arrangements were made through the Experiment Station Directors for the committee to contact all Heads of the Entomology Departments of State Agricultural Experiment Stations and members of their staffs concerned with corn insect problems. Since a well balanced corn insect research program must recognize the need for the support of various scientific disciplines, other scientists who can make vital contributions to this research, such as corn breeders, agronomists, agricultural engineers, and corn pathologists were contacted also. Representatives of hybrid seed producers and processing companies were interviewed in several localities. In making these studies a total of 277 individuals were consulted.



From these specialists the committee obtained information on the most important corn insects, the man-years being currently devoted to corn insect research and suggestions on the type of research needed to reduce the damage caused by the insects. In most cases the committee obtained an estimate of the damage caused by corn insects in various states. Where no loss estimate was obtained, the damage was arrived at by using the percent loss figures from the adjoining state or states.

Because of wide variations in losses from year to year the estimate is based on an average for several years rather than any single year. It should be pointed out that estimates of losses in most cases are not based on statistical surveys and study but rather on the observations and judgment of the specialists. Consequently estimates vary widely depending on the importance of the problem in the different areas and the amount of work done on evaluating losses.

Although the committee discussed insect problems on corn in storage with those consulted and some information is given in the report on these insects, this problem was considered outside of the assigned responsibility of the committee and no estimates of the research needed in this field are given.

The presentation of the findings is given by regions as designated by the Experiment Station Directors, i.e. Northeastern, Southern, Western and North Central. The states in each of these regions are as follows:

<u>Northeastern</u>	<u>Southern</u>	<u>North Central</u>	<u>Western</u>
Connecticut	Alabama	Illinois	Arizona
Delaware	Arkansas	Indiana	California
Maine	Florida	Iowa	Colorado
Maryland	Georgia	Kansas	Idaho
Massachusetts	Kentucky	Michigan	Montana
New Hampshire	Louisiana	Missouri	Nevada
New Jersey	Mississippi	Minnesota	New Mexico
New York	North Carolina	Nebraska	Oregon
Pennsylvania	Oklahoma	North Dakota	Utah
Rhode Island	South Carolina	Ohio	Washington
Vermont	Tennessee	South Dakota	Wyoming
West Virginia	Texas	Wisconsin	
	Virginia		



Importance of Corn to the Nation. Corn is grown in every state in the Union. Approximately 85,000,000 acres or a fifth of the crop land is devoted to the production of corn. The value of the crop is almost five billion dollars per year. Corn is grown on about four million farms or about two-thirds of all farms in the United States.

The income from corn exceeds that of the combined value of the next two most valuable crops which are cotton and wheat. More farmers raise corn than any other crop. Corn directly and indirectly constitutes a larger part of the diet of American people than any other single agricultural crop. This includes corn consumed directly, as milled-corn products, and indirectly in the form of meat, milk, and eggs. Corn is vital to the basic economy of the United States. Whatever influences corn affects all Americans.

While dent corn is by far the most important type of corn grown, the value of sweet corn and popcorn should not be overlooked. Sweet corn occupies about 650,000 acres (200,000 fresh market and 450,000 for processing) and is valued at about \$73,000,000 per year. It is particularly important and necessary that fresh corn be free of insect damage. Popcorn is grown on 160,000 acres with an average annual farm value of \$8,800,000.

As would be expected for a crop grown over such a wide area, corn is subject to insect attack involving a variety of species from the time seed is planted until harvested and subsequently in storage. Estimates made by contacting individuals from each state showed that the average annual loss of corn due to field insects is more than \$900,000,000 a year.



## THE CORN INSECT PROBLEMS

Of the more than 25 species of insects which attack corn in the field, some are important in every region every year. Others, especially some introduced species such as the European corn borer and south-western corn borer occur in large portions of the producing areas and are still spreading to new areas each year.

Table 1 gives the relative rank of the five most important insects in each region. The European corn borer is the most injurious single species. It is spreading farther south and west every year and now occurs in 39 states. In addition to corn it feeds on a large number of other crops. The second most important corn insect is the corn earworm which occurs in every state. It is the most important insect in all regions except the north central and is a limiting factor in the production of fresh market corn. It is an important pest on cotton where it is known as the bollworm and feeds on a large number of other crops including vegetables. Another important species often causing the same type of injury is the fall armyworm. Soil insects which include such species as corn root worms, wireworms, white grubs, seed-corn maggots, and sugarcane beetles, are serious pests throughout the United States. Damage due to soil insects often is not recognized because the insects feed underground. Another corn insect, the south-western corn borer is causing considerable concern because of its rapid spread eastward from Oklahoma and Arkansas in recent years. The rice weevil, a pest that infests corn in the field and continues to feed while in storage is a serious pest throughout the south. The corn leaf aphid is a pest in all areas often causing a reduction in pollen shedding and upsets the physiology of the plant which may result in partial to complete barrenness.

Spider mites in the past usually have not been considered of major importance, as pests of corn, but this survey showed that they are very important in the Western States. Grasshoppers were listed among the five most important insects in the Western and North Central regions. Sap beetles are important sweetcorn pests especially in the Northeast.



Table 1. The five most important corn insects in each of the four regions.

	Northeastern	North Central	Western	Southern
Corn earworm	: European corn borer	: Corn earworm	: Corn earworm	
European corn borer	: Soil insects	: Spider mites	: Soil insects	
Soil insects	: Corn earworm	: Soil insects	: Rice weevil	
Sap beetles	: Grasshoppers	: Corn leaf aphid	: Corn borers	
Fall armyworm	: Corn leaf aphid	: Grasshoppers	: Fall armyworm	



## NATURE AND SCOPE OF CORN INSECT RESEARCH NOW UNDERWAY

Recent Advances In Control Measures For Corn Insects. As a result of research conducted in cooperation with State Agricultural Experiment Stations, progress has been made in the control of corn insects by cultural, biological, and chemical means and by the use of corn inbreds and hybrids resistant to insects.

Much of the research to develop measures for controlling corn insects has centered around applied biological and ecological methods. A good deal of emphasis has been placed on the use of natural enemies, and efforts have been directed toward methods of limiting insect populations through adjustments in plowing and planting time, crop rotation, sanitation, and barriers. The effect of compatible cultural practices in reducing insect abundance in corn is perhaps of greater significance than is commonly appreciated. Many such practices have become established procedure in corn production. Others, such as indiscriminate burning and fall plowing to destroy overwintering forms, have gone into discard with the adoption of better agronomic and soil conservation methods.

The last two decades have seen a general turnover from open pollinated to hybrid varieties of corn. Significantly better in yield and standing ability and in tolerance to insects and diseases, hybrid corn has had a considerable impact on various aspects of research on corn insects.

The development and use of highly efficient insecticides and equipment for applying them have been important factors in the improved control of corn insects. Concurrently a great deal of effort has been devoted to investigating the various aspects of insecticide residues on the crop and the safeguards required in the use of the new insecticides.

In spite of such progress, corn insects still cause an estimated \$900,000,000 damage each year and make it difficult for many farmers to produce corn economically.

Current Status Of Corn Insect Research. Some corn insect research is conducted by 39 of the State Agricultural Experiment Stations. The Department conducts corn insect research at 6 locations all in cooperation with State Agricultural Experiment Stations. The number of man-years and approximate expenditures by regions and by State and Federal agencies is shown in table 2.

A list of insects and the approximate number of entomologists (man-years) devoted to research on each insect is given in table 3. Table 4 gives a summary of the man-years and percent of the total research devoted to each major line of work.



The figures shown do not include research conducted on insects attacking corn in storage.

The States devote approximately three times as much effort on corn insect research as the Department. The total corn insect research conducted by State and Federal agencies, amounts to only .0164 percent of the value of the corn crop or only \$1 for research to every \$6,000 in income. Only \$1 is spent by State and Federal agencies for research in an effort to reduce a loss of \$1,150.



Table 2 - Corn insect research conducted by State and Federal agencies in different regions in relation to total value of the crop and estimated losses caused by insects 1/

Region	Approximate value of corn crop	Estimated loss due to insects	Entomologists assigned to corn insect research		Supporting scientists on insect problems		Percent of value of crop spent on insect research				
			State	Federal	State	Federal					
			Man- years	Amt. 2/ spent	Man- years	Amt. 2/ spent					
North Central	\$3,648,722,175	751,690,636	20.0	:220,000:	8.5	:87,693:	6.4	:71,500:	2.8	:30,800:	.0112
Southern	809,685,000	134,300,000	14.0	:154,000:	6.0	:71,719:	2.2	:24,200:	1.0	:11,000:	.0322
Northeastern	258,715,886	18,359,375	7.0	:77,000:	0	:	.4	:4,400:	0	:	.0315
Western	52,982,219	4,641,074	2.6	:28,600:	0	:	.2	:2,200:	0	:	.0581
Total											
All Regions	\$4,770,105,280	908,991,085	43.6	:479,600:	14.5	:159,412:	9.2	:102,300:	3.8	:41,800:	.0164

1/ Does not include insects attacking stored corn.

2/ Amount spent by States and Federal supporting scientists estimated at the same rate per man-year as Federal entomologists.

3/ Includes corn breeders, chemists, agricultural engineers and corn pathologists, horticulturists, and statisticians.



Table 3 - Man-years now devoted by State and Federal entomologists on each corn insect.

Insect	:Man-years devoted : : to research :		Number of states doing work in each region				
	:Federal :	: State :	: North :		:North- :		
			: Central:	:Southern :	:eastern:	:Western	
Angoumois grain moth (field)	: - :	: .5 :	: 1 :	: 2 :	: - :	: - :	
Bill bugs	: - :	: 1.1 :	: - :	: 3 :	: - :	: - :	
Chinch bug	: - :	: .2 :	: 1 :	: 1 :	: - :	: - :	
Corn earworm	: 4.8 :	: 7.2 :	: 6 :	: 9 :	: 8 :	: 2 :	
Corn flea beetle	: - :	: .6 :	: 1 :	: 2 :	: 1 :	: - :	
Corn leaf aphid	: - :	: .9 :	: 1 :	: - :	: 1 :	: - :	
Cutworms	: - :	: .2 :	: 1 :	: - :	: - :	: 1 :	
European corn borer	: 6.8 :	: 17.5 :	: 11 :	: 6 :	: 7 :	: - :	
Fall armyworm	: .3 :	: .7 :	: 1 :	: 3 :	: 1 :	: 1 :	
Grasshoppers	: - :	: .3 :	: 1 :	: - :	: - :	: - :	
Japanese beetle	: - :	: .1 :	: - :	: - :	: 1 :	: - :	
Lesser cornstalk borer	: - :	: .2 :	: - :	: 1 :	: - :	: 1 :	
Miscellaneous insects	: - :	: .5 :	: 3 :	: 1 :	: - :	: - :	
Mites	: - :	: .6 :	: - :	: - :	: - :	: 4 :	
Rice weevil (field)	: .8 :	: 2.3 :	: - :	: 3 :	: - :	: - :	
Sap beetles	: - :	: 1.3 :	: 1 :	: - :	: 2 :	: - :	
Soil insects	: .6 :	: 8.2 :	: 6 :	: 7 :	: 1 :	: 2 :	
Southern cornstalk borer	: - :	: .2 :	: - :	: 1 :	: - :	: - :	
Southwestern corn borer	: 1.0 :	: .6 :	: 1 :	: 3 :	: - :	: - :	
Sugarcane borer	: .2 :	: .2 :	: - :	: 1 :	: - :	: - :	
Symphylids	: - :	: .2 :	: - :	: - :	: - :	: 2 :	
TOTAL	14.5	43.6	-	-	-	-	



Table 4 - Man-years of entomologists devoted to each major line of research.

Major Project	Man-years devoted		Percent of total	
	to research		devoted to each	
	Federal	State	Federal	State
Biology and Ecology	2.2	11.0	15.2	25.2
Chemical Control	3.3	18.2	22.7	41.8
Plant Resistance	6.6	10.0	45.5	22.9
Biological Control	2.3	2.0	15.9	4.6
Corn disease - Insect complex	-	1.8	0	4.1
Light trap studies	.1	.6	.7	1.4
TOTAL	14.5	43.6	100.0	100.0



Nature of Research on Corn Insects Underway by the Department of Agriculture. Corn insect research is conducted by the Department of Agriculture at six locations. Approximately 14.5 professional man-years is devoted to this work which includes the following 8 line projects.

- Biology and ecology of the European corn borer.
- Chemical control of the European corn borer.
- Plant resistance to the European corn borer.
- Biological control of the European corn borer.
- Biology, ecology, and methods of control of the corn earworm.
- Biology, ecology, and methods of controlling miscellaneous insects attacking corn.
- Plant resistance of corn to rice weevil attack.
- Biology, ecology, and methods of control of soil insects attacking corn.

Headquarters for the Department's research on the European corn borer is at Ankeny, Iowa, with a sub-laboratory at Wooster, Ohio.

There are 7 professional entomologists at Ankeny, Iowa, (one  $\frac{1}{2}$  time with Iowa Agricultural Experiment Station) and one at Wooster, Ohio.

In addition federal contribution to supporting work on European corn borer research consists of approximately  $\frac{1}{2}$  time of an agricultural engineer, two plant breeders, and  $\frac{1}{4}$  time of a chemist.

The main laboratory for research on other corn insects is located at State College, Mississippi, with sub-laboratories at Stillwater, Oklahoma; Lafayette, Indiana; and Tifton, Georgia. Work at these stations is devoted primarily to the corn earworm, southwestern corn borer and rice weevil with some work on soil insects and the fall armyworm. There are 4 entomologists at State College and one at each of the other three stations. Federal corn breeders at State College, Lafayette, and Tifton cooperate on the development of hybrids resistant to insects. This supporting work amounts to about  $\frac{3}{4}$  of a man-year.

An entomologist with the Department's Agricultural Marketing Service spends approximately  $\frac{1}{4}$  of his time on the cooperative rice weevil project.

The Department has recently negotiated a research contract for a three-year study (\$15,000 total) with the Iowa Agricultural Experiment Station to investigate the pathogenic agents affecting corn insects with particular reference to the European corn borer and corn earworm.



Nature of Research on Corn Insects Underway by State Experiment Stations. Research is being conducted by the State Agricultural Experiment Stations on 20 insects. In most states the research is directed to problems of a state-wide nature often designed to develop chemical control recommendations. As shown in table 4, almost 42 percent of the total research by state entomologists is devoted to chemical control as compared to 22.7 percent for federal research. Biology and ecology studies which are often directed toward obtaining information valuable in considering timing of chemical control measures receive considerable attention by state workers. Almost 23 percent of the state research is devoted to control by use of plant resistance. Much of this is basic in nature, especially that devoted to determining the cause of resistance.

In addition to the above, one regional project NC-20 "Factors influencing corn borer populations" which has been active since 1954 is devoted entirely to corn insect problems. States participating in this project are Iowa, Kansas, Minnesota, Missouri, Nebraska, and Ohio. This work was included in tables 2, 3, and 4.

The primary purpose of the NC-20 project is to determine how corn varieties, planting dates, and climatic conditions affect borer population and corn yield in different areas of the North Central States. Presently two additional objectives are being considered. These are (1) to determine the effect of biotic and physical factors that influence corn borer abundance, and (2) to obtain more precise information on the effect of insecticide applications on corn yield in relation to different levels of soil fertility.

Nature of Research on Corn Insects by Industry. In addition to research on corn insects conducted by state and federal agencies, some of the larger seed corn producers, processing plants, and insecticide manufacturers and formulators also conduct important research on corn insects. Most of this relates to chemical control but some seed corn producers devote time to the development of hybrids resistant to insects. No estimate was made of the man-years and funds expended by industry on corn insect research.



## OVERALL RESEARCH NEEDS AS DETERMINED BY THE STUDY

The needs for research on corn insects as expressed by the individuals interviewed by the committee are indicated in table 5. A total of 50 lines of research were suggested. These have been grouped into major subject matter as follows: biology and ecology 17; chemical control including work on insecticide residues 10; plant resistance 7; cultural control 4; biological control 3; role of insects in corn diseases 4; and miscellaneous studies 5. It is interesting to note the large number of basic research projects suggested. Most of the research under biology and ecology, plant resistance and biological control could be considered as basic studies.







Table 5 (Continued)

Type of Research	Number of states in each region making this suggestion				Remarks
	:North :		:North :		
	:Central:	:Southern:	:Eastern:	:Western:	
BIOLOGY AND ECOLOGY OF CORN INSECTS					
d. Determine factors influencing the establishment and growth of corn insects:	3	2	1	0	Important in resistance studies
e. Development of criteria for initiation of control operations	8	5	10	4	Needed for all insects, especially critical and of regional importance for those insects that overwinter in southern areas and migrate northward each year
f. Basic factors influencing the distribution and movement of insects	4	2	1	2	Suggested especially for corn earworm and fall armyworm
g. General biology and ecology studies	6	9	1	2	
h. Taxonomy of insects	3	1	-	-	
i. Hibernation studies	-	1	-	-	
j. Investigate possibility of controlling migrations (fall armyworm)	-	2	-	-	



Table 5 (Continued)

Type of Research	Number of states in each					Remarks
	: region making this					
	: suggestion					
	: North	: North-	: North-	: North-	: North-	
	: Central:	: Southern:	: eastern:	: Western:		
	BIOLOGY AND	ECOLOGY	OF	CORN	INSECTS	
k. Study reasons for insect outbreaks	:	:	:	:	:	Suggested for European corn borer
l. Investigate interbreeding and inheritance of insect bio-types	:	:	:	:	:	Suggested for European corn borer
m. Study factors causing diapause	:	:	:	:	:	Suggested for European corn borer
n. Determine alternate hosts	:	:	:	:	:	Suggested for European corn borer, corn earworm and southwestern corn borer
o. Study ecology and physiology of voltinism	:	:	:	:	:	Suggested for European corn borer
p. Investigate the importance of bio-types by biochemical and physiological means:	:	:	:	:	:	
q. Study the effect of insect infestation on grain quality and germination	:	:	:	:	:	







Table 5 (Continued)

Type of Research	Number of states in each region making this suggestion				Remarks
	: : : :				
	: : : :				
	: : : :				
	:North	:North	:Central	:Western	
	:Southern	:Eastern	:Western		
	: : : :	: : : :	: : : :	: : : :	
	C H E M I C A L	C O N T R O L	S T U D I E S		
i. Study the use of hormones for control	: 1	: -	: -	: -	
j. Develop more uniform hybrids for increased efficiency of chemical control:	: 1	: -	: -	: -	Especially important in corn earworm control
	: : : :	: : : :	: : : :	: : : :	
	P L A N T	R E S I S T A N C E			
a. Field evaluation of resistance whenever damage occurs	: 2	: 6	: 3	: 5	Suggested for all major corn insects
b. Screening of inbreds and hybrids for resistance	: 9	: 10	: 3	: 5	Mentioned for 10 different insects
c. Determine the nature and cause of insect resistance in corn	: 7	: 9	: 2	: 2	
d. Study the inheritance of resistant factors	: 4	: -	: -	: -	
e. Study the genetics of corn insects	: 2	: 1	: -	: -	
f. Determine the cytological basis for insect resistance	: 1	: -	: -	: -	
g. Determine the influence of resistant varieties on population	: 1	: -	: -	: -	







Table 5 (Continued)

Type of Research	Number of states in each				Remarks
	region making this				
	suggestion				
	North	Central	South	West	
ROLE OF INSECTS IN CORN DISEASE					
a. Determine the role soil insects play in root pathogens	2	1	1	-	
b. Investigate the transmission of corn diseases by thrips	1	-	-	-	
c. Determine the role insects play in stalk rot problems	1	-	1	-	
d. Determine the role insects play in bacterial and fungus diseases	1	3	-	-	
MISCELLANEOUS STUDIES					
a. Translate and abstract world-wide corn insect literature	2	-	-	-	
b. Use of light traps for corn insect survey or control	2	-	-	-	
c. Various studies on stored corn insects	3	6	1	1	
d. Nematodes as a factor in corn production	-	3	-	-	
e. Study marketing methods that might reduce insect problems	-	-	-	1	Suggested for corn earworm



The three lines of research under chemical control studies that were suggested most frequently were: improved methods of applying insecticides, screening and evaluating new insecticides, and investigation of insecticide residues. Since DDT is recommended for the control of several corn insects and since forage from corn treated with this insecticide cannot be fed to livestock, the insecticide residue problem is especially critical. In the past, tons of the waste products from sweet corn processing plants have been used for livestock food. Since this practice is now prohibited, where DDT has been used, waste products have become a liability rather than an asset. It is estimated that corn forage from sweet corn is worth approximately \$25 per acre. Since there are about 650,000 acres of sweet corn grown, the residue problem represents a potential \$16,000,000 loss of forage each year. This is in addition to the thousands of acres of dent corn that cannot be used for forage because of residues.

A breakdown of the projects by insects is given in Table 7. The five insects mentioned by most states were corn earworm, European corn borer, soil insects, fall armyworm, and corn leaf aphid. Only two, corn earworm and soil insects, were mentioned by states in all regions.



Table 7. The number of states suggesting research work on various insects.

Insect or Pest	Number of states suggesting work in each region				Total States
	North	North-	North-	North-	
	Central	Southern	eastern	Western	
All Insects	6	10	3	2	21
Armyworm	2	1	1	-	4
Billbugs	-	1	-	-	1
Chinch bug	1	1	-	-	2
Common stalk borer	1	1	-	-	2
Corn earworm	9	13	10	8	40
Corn leaf aphid	6	-	1	1	8
Cutworms	2	1	-	-	3
European corn borer	10	5	8	-	23
Fall armyworm	2	6	2	-	10
False chinch bug	-	1	-	-	1
Flea beetle	1	1	1	-	3
Grasshoppers	1	1	-	1	3
Japanese beetle	1	1	-	-	2
Leafhoppers	1	-	-	-	1
Lesser cornstalk borer	-	2	-	1	3
Mites	-	-	-	6	6
Nematodes	-	3	-	-	3
Rice weevil	-	5	-	-	5
Sap beetles	1	-	4	-	5
Soil Insects	9	10	3	2	24
Stored grain Insects	3	6	1	1	11
Sugarcane beetle	-	2	-	-	2
Southwestern corn borer	2	3	-	1	6
Thrips	1	-	-	-	1



## NATURE OF THE WORK AND REQUIREMENTS FOR A PROPOSED FEDERAL PROGRAM OF RESEARCH

The requirements for a federal program of research are estimated on the premise that federally sponsored investigations should be limited to broad problems that will help provide information generally applicable from a national or regional standpoint. In order to help meet the needs for corn insect research on the major insects of regional and national importance it would seem appropriate for the Federal Government to support investigations on the following 7 insects:

- |                        |                            |
|------------------------|----------------------------|
| 1. Corn earworm        | 5. Corn leaf aphid         |
| 2. European corn borer | 6. Rice weevil             |
| 3. Soil insects        | 7. Southwestern corn borer |
| 4. Fall armyworm       |                            |

On the basis of the study of research needs to help meet the problems of control for the insects listed, involving consultation with many scientists and agricultural administrators, the study committee has developed a proposed program of research above the current federal effort that is regarded appropriate for federal support. The program suggested by the study provides for: (1) some additional support for corn insect research projects now underway in order to permit adequate staffing with subprofessional assistants, and an increase in operating funds; (2) a major expansion of research and the construction of necessary facilities for an adequate federal corn insect research program in the midwest and (3) a major expansion of research and the construction of necessary facilities for an adequate federal corn insect research program in the south.

In order to undertake an adequate program of research to obtain basic information on broad aspects of major corn insect problems it is estimated that two modern research laboratories would be required. One location should be in the midwest, to concentrate on the European corn borer, corn leaf aphid, and certain species of soil insects. Investigations on the other four major insect problems and soil insects could be conducted most effectively in the south.

It is recognized that there are many important corn insect problems in other regions. However, by establishing work in two areas on the insect problems of broad significance, it will be possible to obtain basic information generally applicable for major insect problems throughout the United States.

It would be advantageous to establish the research center near a Land-Grant college in the region. To take full advantage of the existing facilities and personnel it would also be advantageous to locate where federally supported research is now underway.



Such a location would have at least four advantages over one separated from an agricultural experiment station: (1) library facilities would be available; (2) advice, consultation, and other assistance would be available from the experiment station staff; (3) graduate students would be available for part-time employment; (4) expensive equipment and facilities could be shared.

While these laboratories could be located at any of several State Agricultural Experiment Stations in the two regions, it is suggested that State College, Mississippi be considered for the southern laboratory and Ankeny, Iowa (near Iowa State College) for the mid-west. The Department already has considerable corn insect research underway at these locations. Moreover, it has corn breeders engaged in the development of corn insect resistant inbreds and hybrids at these locations, and an agricultural engineer engaged in the development of equipment for the chemical control of corn insects is located at the Iowa station.

The establishment of a basic corn insect research center in each of two areas would permit concentration on those phases of research requiring extensive cooperation among disciplines found in several divisions. Most research problems that require expensive facilities and highly trained specialists could be concentrated at the central locations. Such centers would have the additional advantage that they could serve as an in-service training for new and regular employees on even broader aspects of entomology and related sciences.

Strengthening Existing Work. Research in progress at Ankeny, Iowa; Stillwater, Oklahoma; State College, Mississippi; Wooster, Ohio; Lafayette, Indiana; and Tifton, Georgia, should have substantial increases in number of subprofessional employees to assist the senior scientists and should have additional materials and facilities.

Midwest Federal Laboratory. The lines of research, number and type of senior scientists required and facility needs for the proposed corn insect research center in the mid-west are given below. The research would be concentrated on the European corn borer, corn leaf aphid, soil insects and on certain phases of research on the corn ear worm. The research would be undertaken with a view to obtain information applicable to other regions as well as to the mid-west.



## I. Biology and Ecology

- A. Investigate methods of mass rearing insects including studies on nutritional requirements.

1 Entomologist  
 $\frac{1}{2}$  Biochemist

- B. Investigate factors responsible for insect behavior.

1 Entomologist (Insect Physiologist)

- C. Evaluate insect losses.

$\frac{1}{2}$  Entomologist

- D. Investigate the role insects play in the transmission or cause of corn diseases.

$\frac{1}{2}$  Entomologist  
 $\frac{1}{2}$  Plant Pathologist

## II. Chemical Control

- A. Screening of candidate materials including repellents and attractants.

1 Entomologist  
 $\frac{1}{4}$  Biochemist (to evaluate materials that might be isolated in the nutritional requirement studies and cause of resistance studies for repellents or attractants)

- B. Evaluate insecticides and application equipment in the field, make insecticide residue studies on treated forage and animal products following feeding of treated forage.

1 Entomologist  
 $\frac{1}{2}$  Agricultural Engineer  
 $\frac{1}{2}$  Chemist

## III. Insect Resistance to Corn

- A. Evaluate the resistance of corn inbreds and hybrids to important insects in the Midwest and develop inbreds and hybrids resistant to these insects.

2 Entomologists  
1 Plant Breeder with background in genetics and cytogenetics



B. Investigate factors responsible for corn resistance to insects.

- 1 Entomologist
- $\frac{1}{2}$  Plant Physiologist (to study plant factors concerned with resistance and effect of insect feeding on translocation and the growth response of plants before and after infestation)
- $\frac{1}{4}$  Biochemist (to determine chemical composition of plant factors concerned with resistance)

IV. Biological Control

A. Investigate the use of pathogens for corn insect control.

- 1 Entomologist (Insect Pathologist with good background in bacteriology)

B. Investigate other biological control methods including the use of parasites, predators, and male sterile technique.

- 1 Entomologist

Total staff that would be needed in Midwest laboratory is 10 entomologists and 4 supporting scientists.

Each scientist on the staff should be provided with support sufficient to allow for at least one subprofessional aid.

The buildings and facilities required to conduct the research suggested for the Midwest are as follows:

<u>Facilities</u>	<u>Sq. Ft. of Space</u>
Laboratory	10,500
Office	2,660
Greenhouse	14,000
Headhouse	4,620
Storage, garage and shop	8,400

It is estimated that 60 acres of land for field plots would be required, but because of insecticide accumulations in the soil where chemical control tests are conducted it would be best to rent land for some tests each year instead of having permanent control of all the land.



Southern Federal Laboratory. The southern laboratory would devote major attention to the corn earworm, but would include studies also on the fall armyworm, rice weevil, southwestern corn borer, certain phases of work on the European corn borer, and soil insects. The basic work on corn earworm would be of benefit to the Northeastern and Western regions where this species is the most important corn insect problem. The spread of the southwestern corn borer into the more important corn growing region of the South makes it desirable to intensify research on this insect. Since the European corn borer is also becoming more important in the South it is necessary to develop inbreds and hybrids adapted to the South that are resistant to both of these important borers as well as corn earworm, rice weevil, and fall armyworm.

The nature of the work, additional staff required and estimate of facility needs at the southern laboratory are given below:

## I. Biology and Ecology

- A. Investigate methods of mass rearing insects including studies on nutritional requirements.

3/4 Entomologist  
1/2 Biochemist

- B. Investigate factors responsible for insect behavior.

1/2 Entomologist (Insect physiologist)

- C. Evaluate insect losses.

1/2 Entomologist

- D. Investigate the role insects play in the transmission or cause of corn diseases.

1/4 Entomologist  
1/2 Plant pathologist

## II. Chemical Control

- A. Screening of candidate materials including repellents and attractants.

1 Entomologist  
1/4 Biochemist (to evaluate materials that may be isolated in the nutritional requirement studies and cause of resistance studies for repellents or attractants)



- B. Evaluate insecticides and application equipment in the field, make insecticide residue studies.

$\frac{1}{2}$  Entomologist  
 $\frac{1}{2}$  Agricultural Engineer  
 $\frac{1}{2}$  Chemist

### III. Insect Resistance to Corn

- A. Evaluate the resistance of corn inbreds and hybrids to the corn earworm, fall armyworm, southwestern corn borer, and rice weevil and develop inbreds and hybrids resistant to these and other insects.

1 Entomologist  
1 Plant Breeder with background in cytogenetics and genetics

- B. Investigate factors responsible for corn resistance to insects.

1 Entomologist  
 $\frac{1}{2}$  Plant Physiologist (to study plant factors concerned with resistance and effect of insect feeding on translocation and the growth response of plants before and after infestation)  
 $\frac{1}{4}$  Biochemist (to determine chemical composition of plant factors concerned with resistance)

### IV. Biological Control

- A. Investigate the use of pathogens for corn insect control.

1 Entomologist (Insect Pathologist with good background in bacteriology)

- B. Investigate other biological control methods including the use of parasites, predators, and male sterile technique.

$\frac{1}{2}$  Entomologist

The staff required in the southern laboratory would be 7 entomologists and 4 supporting scientists.

Each scientist on the staff should be provided with support sufficient to allow for at least one subprofessional aid.



The buildings and facilities required to conduct the research suggested for the South are as follows:

<u>Facilities</u>	<u>Sq. Ft. of Space</u>
Laboratory	8,250
Office	2,090
Greenhouse	11,000
Headhouse	3,850
Storage, garage and shop	6,600

It is estimated that 50 acres of land would be required each year for these tests.



Abstracting and Translating Literature On Corn Insects. Progress on all phases of corn insect activities would be greatly accelerated if adequate facilities were provided for abstracting and translating the world literature on corn insects and making such abstracts available to all scientists involved in these investigations. One illustration should be sufficient to show the need in this area. It is known that Russia has done considerable work in the field of plant resistance to insects and at least one book has been published in Russian on this subject but it has not been translated. It is probable that some duplication of effort might be prevented and information on new leads obtained that would permit faster progress if information in foreign publications were available.

Classification Of Corn Insects. The present knowledge of classification of insects attacking corn is inadequate. Accurate identification of species is very important in biological control studies, insect transmission of diseases and with biotype studies on insect resistance to corn. While some information may be gathered by those working on corn insects most of the work must be done by taxonomic specialists in museums, and necessary support for such work is desirable.



## RELATIONSHIP OF PROPOSED FEDERAL PROGRAM TO STATE PROGRAMS

It is emphasized that the Federal program outlined would represent only a portion of the overall research effort required to deal adequately with corn insect problems. Many other insects are injurious to corn in one or more states and these as well as many phases of study on the seven major pests should be investigated. In order to initiate or strengthen research on the many other facets of the corn insect problems that this study has indicated desirable, the committee suggests that State Agricultural Experiment Stations might wish to study the matter and obtain through appropriate sources such additional support as circumstances warrant for their state.

## APPLICATION OF RESEARCH INFORMATION ON CORN INSECTS TO OTHER CROPS

While the studies outlined would be directed toward solving corn insect problems, the information obtained on the control of insects involved would be of great value in the control of insects on other crops. All of the seven insects suggested for study attack sorghum. The corn earworm and fall armyworm attack many vegetables and field crops including cotton. Some species of soil insects are major pests of many crops. The corn leaf aphid attacks many plants of the grass family. Both the European corn borer and southwestern corn borer have a wide range of host plants. Therefore, basic findings and control methods developed in the corn insect program could be expected to be applicable, with some necessary modifications, to many other crops.





